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A COMPUTERIZED METHOD FOR DETERMINATION OF REGIONAL BLOOD FLOW --ETC(U)
MAR 79 K C SMITH, S WARD, K J GREENLEES F33615-76-C-5001
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1 OF 1
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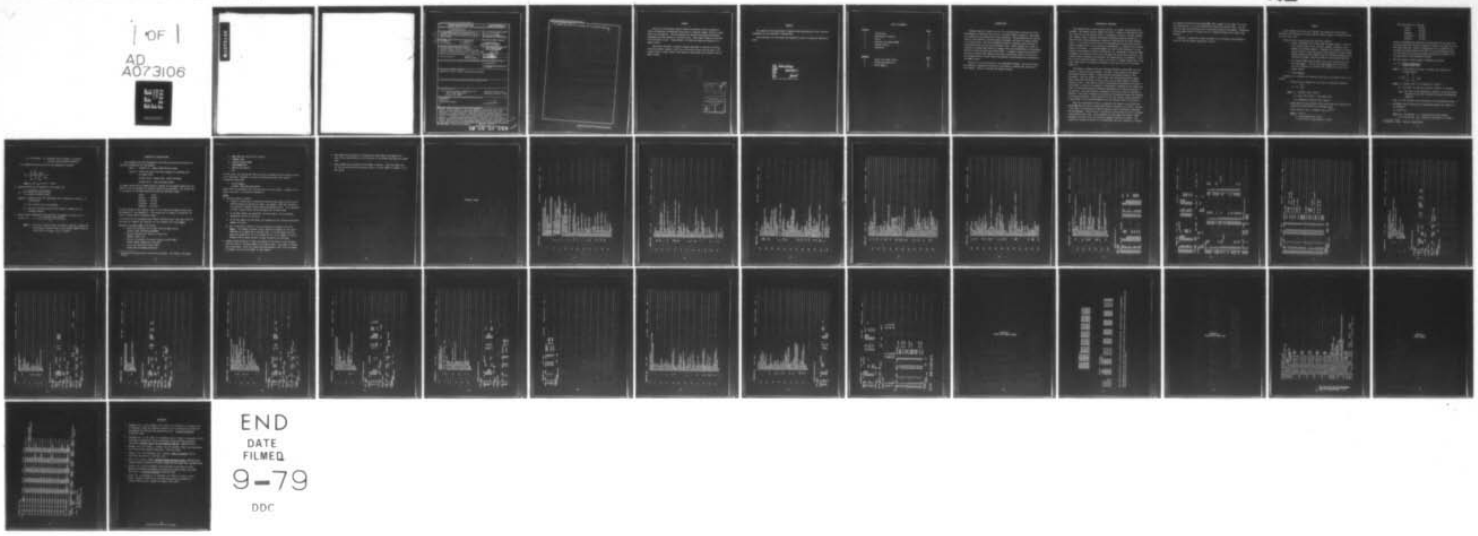

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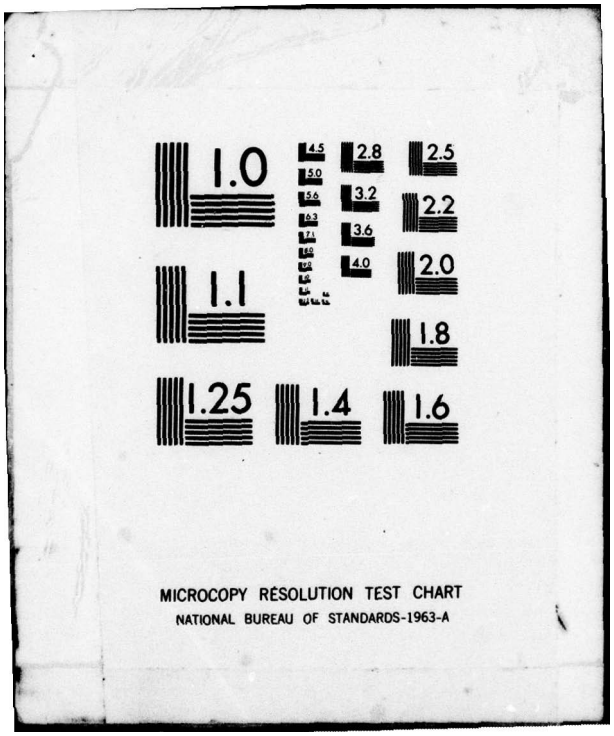
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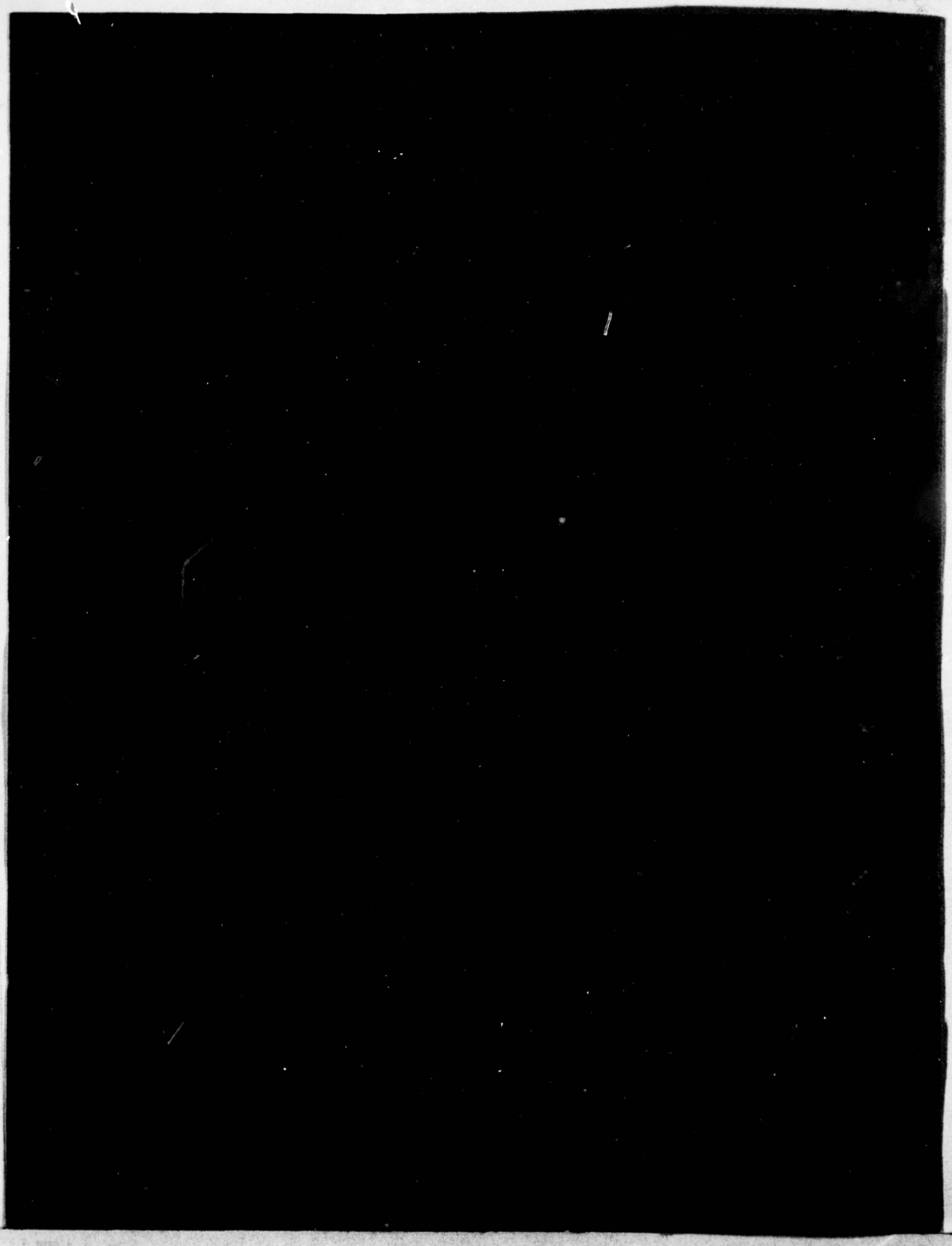

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Studies utilizing radioactive tracer microspheres to determine blood flow to a specific region, tissue, or organ under +G acceleration were done in this Laboratory. The microspheres were injected into animal subjects and were distributed throughout the body. They were trapped in capillary beds according to size. Tissue samples from areas of interest were taken, and radiation measured. A computer program was developed to calculate corrected counts per minute, regional blood flow, and cardiac output from raw data. This report includes a brief outline of the experimental design, the theory behind the

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Block 20. Abstract (cont'd)

program, execution of the program, and the program listing.

SUMMARY

Studies in the Aerospace Medical Research Laboratory utilize radioactive tracer microspheres to determine blood flow to a specific region, tissue or organ under $+G_z$ acceleration. The microspheres are injected and become distributed throughout the body similar to red blood cells. They become trapped in capillary beds according to size. Tissue samples are taken and radiation measured in a gamma counter.

This report describes a computer program developed to calculate corrected counts per minute, regional blood flow, and cardiac output from raw data. The program offers a rapid, easily used method for processing data obtained from the gamma counter.

PREFACE

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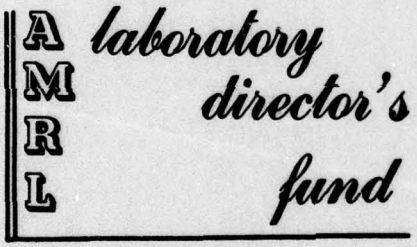

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INTRODUCTION

Studies similar to those of Sostre (7) utilizing plastic radioactive tracer microspheres to calculate blood flow to a specific region, tissue, or organ under $+G_z$ acceleration are being done in this Laboratory. The microspheres are injected into the left ventricle, and distributed throughout the body in a manner similar to red blood cells. They are entrapped in specific capillary beds according to blood distribution and the size microsphere used. Tissue samples from areas of interest are weighed and placed in a gamma counter for determination of microsphere density in terms of counts per minute (CPM). A computer program was developed to calculate corrected CPM, regional blood flow, and cardiac output from raw data. This program offers a rapid, easily used method for processing data obtained from the gamma counter.

Section 2 is a brief outline of the experimental design. The theory behind the program is presented in Section 3, and Section 4 contains the execution of the program. Section 5 includes the program listing.

EXPERIMENTAL PROCEDURE

The animals used, in this instance baboons, are lightly anesthetized with ketamine. Two femoral artery cutdowns are made; a catheter is inserted into the left ventricle via one femoral artery. Microsphere injections are made through this catheter using a remotely controlled microsphere injection system (2). A small silicone coated polyethylene catheter is inserted into the other femoral artery. It is placed with the tip in the descending aorta just below the arch. Fifteen seconds prior to the injection of microspheres, a constant rate reference sample is withdrawn. A Harvard Pump ® (7) is used in this Laboratory, but any constant rate withdrawal system is acceptable. (6) Withdrawal of blood continues throughout the injection series until one minute after the final injection. The volume of blood withdrawn is calculated, and radioactivity is determined. Blood flow to this reference sample is taken to be that of a "known" organ; flow to any other organ then be calculated by relating to the blood flow of the reference sample (1).

The animal is placed in the Oloff Primate Restraint System (PRS) (5), and allowed to recover from the ketamine. The PRS is then placed on the Dynamic Environment Simulator (DES), a large man-rated centrifuge located in this Laboratory. When the animal is fully awake, the acceleration profile begins. Peak acceleration is either at $+3G_z$ or $+5G_z$, with an equal number of animals exposed to each. Five types of 15 micron radiolabeled microspheres are used for each animal: Cerium 141, Chromium 51, Strontium 85, Scandium 46, and Iodine 125. 0.025 to 0.050 microcuries are injected, depending on the relative activity of the isotope. The first isotope is injected at $+1G_z$ and is used to establish a baseline. When peak acceleration is reached, the remaining isotopes are injected at 30 second intervals. After injection of the last isotope, peak acceleration is maintained for 30 seconds bringing total $+G_z$ exposure time to 120 seconds.

When the acceleration profile is completed, the animal is sacrificed with Uthanol ®, and the brain is removed and fixed in formalin for 72 hours. One half of the brain is sectioned into various regions, such as brainstem, cerebellum, and hypothalamus. The other half is placed in several vials and used to estimate total cerebral blood flow. Tissue samples are also taken from various organs throughout the body, with each location assigned a specific ID number. All samples are weighed and placed in an appropriate vial to be counted in a Packard

Auto-Gamma Scintillation Spectrometer®. When a sample is too large to fit into one counting vial, it can be sectioned and placed into several vials. All the vials can then be incorporated into a group and treated as one sample. Information from the gamma counter is printed out on a standard teletype with a punch tape capacity.

Disposal of radioactive animal carcasses is in accordance with Appendix B, Title 10, Code of Federal Regulations, Part 20.

THEORY

Program GAMMA was written for a Control Data Corporation 6600 computer located at the Aeronautical Systems Division Computer Center at Wright-Patterson Air Force Base, Ohio.

There are three steps involved in using this program:

1. Create a permanent file of data from the gamma counter. This file will contain counts of all reference samples, standards, assay samples, and residue samples. Standards are aliquots of the microsphere solution of the same age as those injected into the animals. Residue samples include samples from the withdrawn catheters, post-experiment syringes, injection catheters, and manifold washouts.
2. Run program GAMMA using the above file, which is given the local file name Tape 1. A local file named Tape 2 will be created, this file contains the corrected CPM, regional blood flow, and cardiac output.
3. Catalog Tape 2.

Computation of corrected CPM, regional blood flow, and cardiac output is as follows:

1. Counts from all samples are corrected for background radiation:

$$c'_i = c_i - \frac{e_i^2}{c_i}$$

where c_i = original count, window i

e_i = mean count window i, from empty vials

c'_i = background corrected count, window i

2. Counts made on days previous to the assay counts are corrected for radioactive decay during the intervening time:

decay corrected count = original count x $e^{(ct/h)}$

where $c = \ln(.5)$

t = days elapsed since count

h = half-life of given isotope, in days

Half-life values (4) used are:

Iodine	60 days
Cerium	32 days
Chromium	28 days
Strontium	64 days
Scandium	84 days

Counts of standards are corrected for decay using the same half-life for each window; the isotope is assumed to decay at the same rate over the entire spectrum. Counts of samples that are not standards are corrected for decay using the half-life of the corresponding isotope for each window; the decay rate within each window is assumed to be the decay rate of the predominant isotope.

3. The total amount of each isotope is computed as follows:

$$z_i = y_i \times \frac{\text{volume injected (ml)}}{\text{volume counted (ml)}}$$

where z_i = total amount of isotope i injected, not corrected for residue samples

$$y_i = \frac{1}{n_i} \sum_{k=1}^{n_i} \sum_{j=1}^{5} c_{ijk}$$

where y_i = average count of the standard for isotope i

n_i = the number of times the count for isotope i is repeated

c_{ijk} = the count of the standard for isotope i in the jth window repeated the kth time, corrected for decay and background radiation

Thus y_i is the average of the total counts in all windows from isotope i.

4. Corrected counts (corrected for overlapping windows) are computed by the formula*:

$$T = (F'F)^{-1} F'C$$

where T is a 5x1 matrix; t_i = corrected counts from isotope i

F is a 5x5 matrix; f_{ij} = proportion of isotope i in window j

* Rosenblatt, Judah. Personal communication

C is a 5x1 matrix; c_j = observed count in window j, corrected for decay and background radiation

F is estimated from the counts of the standards as follows:

$$f_{ij} = \frac{\frac{1}{n_i}\sum_{k=1}^{n_i} c_{ijk}}{\sum_{i=1}^{5} \frac{1}{n_i}\sum_{k=1}^{n_i} c_{ijk}}$$

where n_i and c_{ijk} are as in 3 above

5. Regional blood flow is computed by the formula (5):

$$g_i = \frac{t_i \text{ x withdrawal rate (ml/min)}}{r_i \text{ x weight of sample (grams)}}$$

where g_i = regional blood flow immediately after injection of isotope i, in [ml/min/gram]

t_i = the corrected count from isotope i

r_i = the sum of corrected counts from isotope i, summed over all reference samples

6. Cardiac output immediately after injection of isotope i is given by the formula (3): $s_i = \frac{w_i \text{ x withdrawal rate (ml/min)}}{r_i}$

where w_i = the total corrected count of isotope i injected, computed by subtracting corrected counts of all residue samples from the total count of isotope i (z_i in 3 above).

EXECUTION OF PROGRAM GAMMA

The permanent data file described in the theory section should contain the following information for each sample:

Line 1 Columns 1-6: sample identification number

Lines 2-6 Counts for each of the five isotopes in ascending order by energy level

Columns 15-20: energy level, center of window

Columns 50-55: count for given window

The sample identification number should be unique; no two samples should have the same ID, with the exception of multiple counts of the standards. The energy level at the center of the window should be within the following ranges:

Iodine	29-35
Cerium	142-148
Chromium	317-323
Strontium	511-517
Scandium	1117-1123

The above format is the standard output of the Packard Auto-Gamma Scintillation Spectrometer R (see Appendix A). The program can be changed to accomodate the use of a counter with a different format.

If the data from an experiment are on several different paper tapes they should be read into the computer and combined into one permanent file using Editor.

Execution of program GAMMA is as follows:

1. Attach the permanent file of data from the gamma counter
   ATTACH, TAPE1, PFN,CY=XX,ID=XXXXXX
2. Request permanent file space for output file
   REQUEST, TAPE2, *PF
3. Attach the permanent file which contains program GAMMA
   ATTACH, GAMMA, WARD35,CY=1,ID=L740530
4. Attach the subroutine library IMSL*
   ATTACH,IMSL,ID=LIBRARY,SN=ASD,MR=1

---

* International Mathematical & Statistical Libraries. ASD Computer Subprogram Library

5. Make IMSL part of the local library
   LIBRARY, IMSL
6. Compile program GAMMA
   FTN(I=GAMMA,L=0)
7. Execute the program
   LGO

At this point, the program will ask for certain information which should be typed in as requested. Appendix B contains an abbreviated sample with typed-in information underlined.

8. Catalog Tape 2
   CATALOG, TAPE2,PFN,CY=XX,RP=999

where PFN is the permanent file name and XX is the cycle number. A sample of the output from Tape 2 is included in Appendix C.

NOTES:

1. Entering sample ID numbers
   a. A group of numbers may be entered by putting a minus sign in front of the selected number satisfying the range. For example, "580 -592" specifies all thirteen ID numbers between and including 580 and 592. It is important to leave a space between the first number and the minus sign.
   b. If too many numbers are specified, the extra numbers will be dropped starting at the end of the list.
   c. If too few numbers are specified, the program will not continue until more numbers are given.
   d. Do not include ID numbers in the list which do not exist in the file Tape 1. For example, suppose a group consists of samples 33 -45, and 47 and there is no sample 46 in the data file. If the ID numbers for the group are specified as "33 -47" instead of "33 -45 47" sample 47 will be dropped from the group because too many ID numbers are specified.
2. Samples counted previous to assay are grouped by the number of days elapsed from the count of the given sample to the assay counts. Any number of groups may be specified. After all groups have been entered, enter 0 for the number of samples, and 0 for the number of days elapsed.

3. When sample ID and weight are requested for each sample, the sample ID to enter is the identification of the location in the animal from which the sample came.

4. Assay samples may be grouped in any number of groups. After the sample IDs for the last group have been entered, enter 0 for the number of samples in the next group.

PROGRAM LISTING

```
      PROGRAM GAMMA(INPUT,OUTPUT,TAPE1,TAPE2)
      DIMENSION BACK(5),CVOL(5),TVOL(5),Q(5,5)
      DIMENSION REF(5),KS(50),KC(200),NGP(200),KGP(200,2)
      DIMENSION KSI(50),NTOT(5)
      DIMENSION NSCEL(200),DAY(200)
      DIMENSION MGP(200)
      DIMENSION KDUM(200),IN(5),ICT(5),LIMN(5),XCT(5),RCT(5)
      DIMENSION TOT(5),SSGP(200,5),FLOW(5),KREF(20),PER(5,5)
C
C     TO CHANGE # ISOTOPES
C       CHANGE DATA STATEMENTS FOR LIMN, REF AND BACK
C       CHANGE DIMENSIONS OF SSGP,PER AND Q
C       CHANGE VALUE OF "NIS" -- # OF ISOTOPES
C       INCREASE DIMENSIONS OF ALL RELEVANT VARS IF NECESSARY
C       CHANGE DIMENSIONS IN SUBROUTINES INV AND ICLS
C
      DATA LIMN/32,145,320,514,1120/
C     DATA LIMN/32,320,514,1120,0/
      DATA REF/5HI125 ,5HCE145,5HCR141,5HSR85 ,5HSC46 /
C     DATA REF/5HI125 ,5HCR141,5HSR85 ,5HSC46 ,5H     /
      DATA BACK/79.,74.,19.,32.,4./
      PRINT 1
    1 FORMAT(*1CORRECTED MICROSPHERE COUNTS*/)
C     NIS=4
      NIS=5
      PRINT 400,NIS,(REF(I),I=1,NIS)
  400 FORMAT(* NUMBER OF ISOTOPES ASSUMED TO BE*,I3/
     1 * ISOTOPES *,10A6)
      PRINT 5
    5 FORMAT(* ENTER SUBJECT ID *)
      READ 3,SUBJ
      PRINT 2
    2 FORMAT(* ENTER EXPERIMENT DATE *)
      READ 3,DATE
      PRINT 4
    4 FORMAT(* ENTER ASSAY DATE *)
      READ 3,ASSAY
    3 FORMAT(A10)
      WRITE(2,107)SUBJ,DATE,ASSAY
  107 FORMAT(3A10)
      IT=0
      DO 62 I=1,NIS
      PRINT 7,I,REF(I)
    7 FORMAT(* ISOTOPE *,I2,1X,A5)
      PRINT 403
  403 FORMAT(5X,*ENTER VOLUME COUNTED *)
      READ *,CVOL(I)
      PRINT 404
  404 FORMAT(5X,*ENTER VOLUME INJECTED *)
      READ *,TVOL(I)
      PRINT 405
  405 FORMAT(5X,*ENTER # SAMPLE IDS *)
      READ*,NKS
      IF(NKS.LE.0)GO TO 62
      PRINT 14
      CALL NUMB(NKS,KDUM)
      DO 63 J=1,NKS
```

```
                IT=IT+1
                KS(IT)=KDUM(J)
 60       63    KST(IT)=I
          62    CONTINUE
                PRINT 120
          120   FORMAT(* ENTER # REFERENCE SAMPLES *)
                CALL REFIO(NREF,KREF,RCT,REF,NIS)
 65             PRINT 6
          6     FORMAT(* ENTER WITHDRAWAL RATE, REFERENCE SAMPLE *)
                READ *,WITHD
                PRINT 10
          10    FORMAT(* ENTER # SAMPLES FROM RESIDUE *)
 70             READ *,NCATH
                IF(NCATH.LE.0)GO TO 110
                PRINT 14
                CALL NUMB(NCATH,KC)
          110   PRINT 108
 75       108   FORMAT(* ENTER # SAMPLES COUNTED PREVIOUS TO ASSAY*)
                I=0
          53    PRINT 50
          50    FORMAT(3X,* ENTER # SAMPLES AND # DAYS ELAPSED *)
                READ *,NSS,DDD
 80             IF(NSS.LE.0)GO TO 51
                PRINT 14
                CALL NUMB(NSS,KDUM)
                DO 52 K=1,NSS
                I=I+1
 85             NSDEL(I)=KDUM(K)
          52    DAY(I)=DDD
                GO TO 53
          51    NDEL=I
                NGPS=IE=0
 90             IB=I=1
          16    PRINT 11,I
          11    FORMAT(* ENTER # SAMPLES IN GROUP*,I3,1X)
                READ *,NGP(I)
                IF(NGP(I).LE.0)GO TO 13
 95             NGPS=I
                PRINT 14
          14    FORMAT(5X,*ENTER SAMPLE IDS *)
                CALL NUMB(NGP(I),KDUM)
                IE=IB-1+NGP(I)
100             K=0
                DO 15 J=IB,IE
                K=K+1
                KGP(J,1)=KDUM(K)
          15    KGP(J,2)=I
105             IB=IE+1
                I=I+1
                GO TO 16
                *
                *   PROCESS STANCARDS AND REFERENCE SAMPLES
110             *
          13    REWIND 1
                NREF=0
                DO 130 I=1,NIS
                NTOT(I)=0
```

```
115                TOT(I)=0.
                   DO 130 J=1,NIS
             130   PER(I,J)=0.
             135   READ(1,17)IID,((IW(I),ICT(I)),I=1,NIS)
              17   FORMAT(I6/(14X,I6,29X,I6))
128                IF(EOF(1))131,132
                   *    CHECK IF A STANDARD
             132   DO 133 I=1,IT
                   IF(IID.NE.KS(I))GO TO 133
                   CALL WINDOW(IID,IW,ICT,LIMW,NIS,BACK)
125                IS=KST(I)
                   IF(IS.LE.0.OR.IS.GT.NIS)STOP "INDEX"
                   CALL HALF(IID,ICT,NDEL,NSDEL,DAY,IS,NIS)
                   NTOT(IS)=NTOT(IS)+1
                   DO 134 J=1,NIS
138                *
                   *    TOT(IS) = SUM FOR ISOTOPE IS OVER ALL WINDOWS
                   *
                   TOT(IS)=TOT(IS)+ICT(J)
             134   PER(IS,J)=PER(IS,J)+ICT(J)
135                GO TO 135
             133   CONTINUE
                   *    CHECK IF A REFERENCE
                   IF(NREF.LE.0)GO TO 135
                   DO 136 I=1,NREF
140                IF(IID.NE.KREF(I))GO TO 136
                   CALL HALF(IID,ICT,NDEL,NSDEL,DAY,0,NIS)
                   CALL WINDOW(IID,IW,ICT,LIMW,NIS,BACK)
                   NREF=NREF+1
                   DO 137 J=1,NIS
145          137   RCT(J)=RCT(J)+ICT(J)
                   GO TO 135
             136   CONTINUE
                   GO TO 135
             131   DO 150 I=1,NIS
150                SUM=0.
                   DO 151 J=1,NIS
             151   SUM=SUM+PER(I,J)
                   IF(SUM.GT.0.)GO TO 150
                   PRINT 300,I
155          300   FORMAT(* NO STANDARD FOUND FOR ISOTOPE*,I3/
                  1 * ENTER CPM FOR EACH WINDOW*)
                   DO 301 J=1,NIS
                   PRINT 302,J
             302   FORMAT(5X,*WINDOW *,I2,1X)
160                READ *,PER(I,J)
             301   TOT(I)=TOT(I)+PER(I,J)
                   NTOT(I)=NTOT(I)+1
                   *    PER(I,J) IS THE COUNT OF ISOTOPE I IN WINDOW J
             150   CONTINUE
165                *
                   *    COMPUTE FREQUENCY ARRAY
                   *
                   DO 65 I=1,NIS
                   IF(NTOT(I).LE.0)STOP "STANDARD"
170                XX=1./NTOT(I)
                   TOT(I)=TOT(I)*XX
```

```
                DO 65 J=1,NIS
          65    PER(I,J)=PER(I,J)*XX
                IF(NREF.EQ.NREF)GO TO 160
175             PRINT 161,NREF,NREF
          161   FORMAT(* # REF SAMPLES FOUND*,I3,5X,*# SPECIFIED*,I3)
                CALL REFID(NREF,KREF,RCT,REF,NIS)
                GO TO 13
          160   DO 140 I=1,NIS
180             SUM=0.
                DO 141 J=1,NIS
          141   SUM=SUM+PER(I,J)
                SUM=1./SUM
                DO 142 J=1,NIS
185       142   PER(I,J)=PER(I,J)*SUM
          140   CONTINUE
                CALL INV(PER,NIS,Q)
                *     COMPUTE CORRECTED CPMS FOR REFERENCE SAMPLES
                DO 143 I=1,NIS
190       143   ICT(I)=RCT(I)
                CALL CPM(ICT,RCT,PER,NIS,Q)
                PRINT 61,(ICT(I),I=1,NIS)
                PRINT 402,(RCT(I),I=1,NIS)
          61    FORMAT(/* REF CPM  *,5I10)
195       402   FORMAT(* CORR CPM  *,5F10.0)
                DO 411 I=1,NIS
          411   TOT(I)=TOT(I)*TVOL(I)/CVOL(I)
                PRINT 500,TOT
          500   FORMAT(/* SYRINGE*,5G12.5/)
200             *
                *     PROCESS ASSAY SAMPLES AND RESIDUE SAMPLES
                *
          180   REWIND 1
                REWIND 2
205             DO 22 J=1,200
                MGP(J)=0
                DO 22 I=1,NIS
          22    SSGP(J,I)=0.
                LET=1HS
210       25    READ(1,17)IID,((IW(I),ICT(I)),I=1,NIS)
                IF(EOF(1))180,101
                *     CHECK IF DELAY CORRECTION
          101   CALL HALF(IID,ICT,NDEL,NSDEL,DAY,0,NIS)
                *     CHECK IF A STANDARD
215             DO 23 I=1,IT
                IF(IID.EQ.KS(I))GO TO 25
          23    CONTINUE
                *     CHECK IF A REFERENCE SAMPLE
                IF(NREF.LE.0)GO TO 170
220             DO 171 I=1,NREF
                IF(IID.EQ.KREF(I))GO TO 25
          171   CONTINUE
          170   CALL WINDOW(IID,IW,ICT,LIMW,NIS,BACK)
                CALL CPM(ICT,XCT,PER,NIS,Q)
225             *     CHECK IF FROM RESIDUE SAMPLE
                IF(NCATH.LE.0)GO TO 34
                DO 30 I=1,NCATH
                IF(IID.NE.KC(I))GO TO 30
```

```
      DO 31 J=1,NIS
230   31  TOT(J)=TOT(J)-XCT(J)
      GO TO 25
      30  CONTINUE
      *   CHECK IF IN A GROUP
      34  IF(IE.LE.0)GO TO 35
235       DO 33 I=1,IE
          IF(IID.NE.KGP(I,1))GO TO 33
          IGP=KGP(I,2)
          PRINT 230,IID,IGP
      230 FORMAT(I5,' IN GROUP',I3)
240       DO 36 J=1,NIS
      36  SSGP(IGP,J)=SSGP(IGP,J)+ICT(J)
          NGP(IGP)=NGP(IGP)+1
          GO TO 25
      33  CONTINUE
245   35  PRINT 40,IID
      40  FORMAT(' SAMPLE',I5,' -- ENTER SAMPLE ID AND WEIGHT (G) ')
          READ *,KID,WT
          DO 42 I=1,NIS
          FLOW(I)=0.
250       IF(RCT(I).EQ.0.0)GO TO 42
          FLOW(I)=XCT(I)*WITHD/(RCT(I)*WT)
      42  CONTINUE
          WRITE(2,44)LET,IID,KID,WT,(XCT(I),I=1,NIS)
      44  FORMAT(A1,2I5,6G12.5)
255       WRITE(2,401)(FLOW(I),I=1,NIS)
      401 FORMAT(23X,5G12.5)
          GO TO 25
      100 LET=1HG
          IFL=0
260       IB=1
          IF(IE.LE.0)GO TO 333
          DO 200 I=1,NGPS
          IF(NGP(I).EQ.NGP(I))GO TO 203
          IFL=1
265       PRINT 201,I,NGP(I),NGP(I)
      201 FORMAT(' GROUP',I3,'  # SAMPLES FOUND',I3,'  # SPECIFIED',I3)
      203 IF(IFL.EQ.0)GO TO 204
          PRINT 11,1
          READ *,NGP(I)
270       PRINT 14
          CALL NUMB(NGP(I),KDUM)
          IE=IB-1+NGP(I)
          K=0
          DO 202 J=IB,IE
275       K=K+1
          KGP(J,1)=KDUM(K)
      202 KGP(J,2)=I
          IB=IE+1
          GO TO 200
280   204 IB=IB+NGP(I)
      200 CONTINUE
          IF(IFL.NE.0)GO TO 100
          DO 190 I=1,NGPS
          DO 191 J=1,NIS
285   191 ICT(J)=SSGP(I,J)
```

```
                CALL CPM(ICT,XCT,PER,NIS,Q)
                PRINT 192,I
            192 FORMAT(* GROUP #*,I3,* -- ENTER SAMPLE ID AND WEIGHT (G) *)
                READ *,KID,WT
    290         DO 193 J=1,NIS
                FLOW(J)=0.
                IF(RCT(J).EQ.0.0)GO TO 193
                FLOW(J)=XCT(J)*WITHD/(RCT(J)*WT)
            193 CONTINUE
    295         WRITE(2,44)LET,I,KID,WT,(XCT(J),J=1,NIS)
                WRITE(2,401)(FLOW(J),J=1,NIS)
            190 CONTINUE
                *  CARDIAC OUTPUT
            333 PRINT 240,(TOT(J),J=1,NIS)
    300     240 FORMAT(* CPM OF ISOTOPE INJECTED*/5X,5G12.5)
                DO 241 I=1,NIS
                IF(RCT(I).EQ.0.0)GO TO 220
                TOT(I)=TOT(I)*WITHD/RCT(I)
                GO TO 241
    305     220 TOT(1)=0.
            241 CONTINUE
                PRINT 242,(TOT(J),J=1,NIS)
            242 FORMAT(* CARDIAC OUTPUT AT EACH ISOTOPE (ML/MIN)*/5X,5G12.5)
                LET=1HS
    310         WRITE(2,44)LET
                LET=1HF
                WRITE(2,243)LET,SUBJ,DATE,ASSAY,(TOT(J),J=1,NIS)
            243 FORMAT(A1,1X,3A10,5G12.5)
                CALL EXIT
    315         END
```

SYMBOLIC REFERENCE MAP (R=1)

ENTRY POINTS
10266 GAMMA

VARIABLES	SN	TYPE	RELOCATION				
12302 ASSAY		REAL		12332 BACK	REAL	ARRAY	
12337 CVOL		REAL	ARRAY	12301 DATE	REAL		
14530 DAY		REAL	ARRAY	12312 DOD	REAL		
17566 FLOW		REAL	ARRAY	12277 I	INTEGER		
12317 IB		INTEGER		15665 ICT	INTEGER	ARRAY	
12316 IE		INTEGER		12331 IFL	INTEGER		
12326 IGP		INTEGER		12321 IID	INTEGER		
12322 IS		INTEGER		12303 IT	INTEGER		
15560 IW		INTEGER	ARRAY	12305 J	INTEGER		
12313 K		INTEGER		12471 KC	INTEGER	ARRAY	
15350 KDUM		INTEGER	ARRAY	13311 KGP	INTEGER	ARRAY	
12327 KID		INTEGER		17673 KREF	INTEGER	ARRAY	
12407 KS		INTEGER	ARRAY	14131 KST	INTEGER	ARRAY	
12325 LET		INTEGER		15672 LIMW	INTEGER	ARRAY	
15040 MGP		INTEGER	ARRAY	12320 MREF	INTEGER		
12310 NCATM		INTEGER		12314 NDEL	INTEGER		

VARIABLES	SN	TYPE	RELOCATION				
13001	NGP	INTEGER	ARRAY	12315	NGPS	INTEGER	
12276	NIS	INTEGER		12344	NKS	INTEGER	
12306	NREF	INTEGER		14220	NSDEL	INTEGER	ARRAY
12311	NSS	INTEGER		14213	NTOT	INTEGER	ARRAY
17717	PER	REAL	ARRAY	12351	Q	REAL	ARRAY
15734	RCT	REAL	ARRAY	12402	REF	REAL	ARRAY
15716	SSGP	REAL	ARRAY	12300	SUBJ	REAL	
12323	SUM	REAL		15711	TOT	REAL	ARRAY
12344	TVOL	REAL	ARRAY	12307	WITHD	REAL	
12330	WT	REAL		15677	XCT	REAL	ARRAY
12324	XX	REAL					

FILE NAMES	MODE								
0 INPUT	MIXED	2054	OUTPUT	FMT	4138	TAPE1	FMT	6204	TAPE2 FMT

EXTERNALS	TYPE	ARGS				
CPM		5	EOF	REAL	1	
EXIT		0	HALF		7	
INV		3	NUMB		2	
REFID		5	WINDOW		6	

STATEMENT LABELS									
11447	1	FMT	11507	2	FMT	11534	3	FMT	
11523	4	FMT	11473	5	FMT	11636	6	FMT	
11553	7	FMT	11653	10	FMT	11725	11	FMT	
10501	13		11741	14	FMT	0	15		
10441	16		11757	17	FMT	0	22		
0	23		11025	25		11104	30		
0	31		11134	33		11107	34		
11137	35		0	36		12103	40	FMT	
11152	42		12127	44	FMT	11703	50	FMT	
10435	51		0	52		10412	53		
12034	61	FMT	10364	62		0	63		
0	65		11167	100		0	101	INACTIVE	
11544	107	FMT	11672	108	FMT	10407	110		
11626	120	FMT	0	130		10621	131		
0	132	INACTIVE	10572	133		0	134		
10522	135		10616	136		0	137		
0	140		0	141		0	142		
0	143		10660	150		0	151		
10716	160		12016	161	FMT	11063	170		
0	171		11003	180		0	190		
0	191		12175	192	FMT	11277	193		
11244	200		12147	201	FMT	0	202		
11205	203		11242	204		11331	220		
12074	230	FMT	12231	240	FMT	11332	241		
12242	242	FMT	12265	243	FMT	11766	300	FMT	
0	301		12002	302	FMT	11316	333		
11461	400	FMT	12136	401	FMT	12040	402	FMT	
11562	403	FMT	11575	404	FMT	11610	405	FMT	
0	411		12050	500	FMT				

LOOPS	LABEL	INDEX	FROM-TO	LENGTH	PROPERTIES
10317	62	* I	42 61	508	EXT REFS NOT INNER
10357	63	J	57 60	48	INSTACK
10427	52	K	83 86	48	INSTACK
10470	15	J	101 104	48	INSTACK

LOOPS	LABEL		INDEX	FROM-TO	LENGTH	PROPERTIES
10505	130	*	I	113 117	15B	NOT INNER
10514	130		J	116 117	2B	INSTACK
10525		*	I	118 118	10B	EXT REFS
10542	133	*	I	122 136	33B	EXT REFS EXITS NOT INNER
10564	134		J	129 134	5B	INSTACK
10577	136	*	I	139 147	22B	EXT REFS EXITS NOT INNER
10611	137		J	144 145	3B	INSTACK
10622	150	*	I	149 164	41B	EXT REFS NOT INNER
10630	151		J	151 152	3B	INSTACK
10640	301	*	J	157 161	16B	EXT REFS
10664	65	*	I	168 173	24B	EXT REFS NOT INNER
10701	65		J	172 173	3B	INSTACK
10717	140	*	I	179 186	30B	NOT INNER
10725	141		J	181 182	3B	INSTACK
10740	142		J	184 185	3B	INSTACK
10753	143		I	189 190	3B	INSTACK
10775	411		I	196 197	3B	INSTACK
11010	22	*	J	205 208	14B	NOT INNER
11016	22		I	207 208	2B	INSTACK
11030		*	I	210 210	10B	EXT REFS
11046	23	*	I	215 217	5B	INSTACK EXITS
11056	171	*	I	220 222	5B	INSTACK EXITS
11072	30	*	I	227 232	15B	EXITS NOT INNER
11108	31		J	229 230	3B	INSTACK
11112	33	*	I	235 244	25B	EXT REFS EXITS NOT INNER
11125	36		J	240 241	4B	INSTACK
11146	42		I	248 252	5B	INSTACK
11174	200	*	I	262 281	53B	EXT REFS NOT INNER
11232	202		J	274 277	4B	INSTACK
11251	190	*	I	283 297	45B	EXT REFS NOT INNER
11256	191		J	284 285	3B	INSTACK
11273	193		J	290 294	5B	INSTACK
11326	241		I	301 306	5B	INSTACK

STATISTICS

PROGRAM LENGTH	74748	3900
BUFFER LENGTH	102608	4272

52000B CM USED

```
      SUBROUTINE CPM        74/74   OPT=1                    FTN 4.6+446      08/21/78  15.48.36    PAGE   1

      1                     SUBROUTINE CPM(ICT,XCT,PER,NIS,Q)
                            DIMENSION ICT(NIS),XCT(NIS),PER(NIS,NIS)
                            DIMENSION Q(NIS,NIS)
                      *     PER IS INV(A *A TRANS) * A
      5               *        WHERE A(I,J) IS THE PROPORTION OF COUNTS FROM ISOTOPE
                      *        I IN WINDOW J
                      *        SUM OF A(I,J) OVER J FOR FIXED I IS 1.0
                            DO 5 I=1,NIS
                            XCT(I)=0.
     10                     DO 4 J=1,NIS
                          4 XCT(I)=XCT(I)+PER(I,J)*ICT(J)
                          5 CONTINUE
                            CALL ICLS(Q,XCT,NIS)
                            RETURN
     15                     END


        SYMBOLIC REFERENCE MAP (R=1)

    ENTRY POINTS
        3  CPM

22  VARIABLES     SN  TYPE          RELOCATION
       54  I         INTEGER                          0  ICT       INTEGER    ARRAY    F.P.
       55  J         INTEGER                          0  NIS       INTEGER               F.P.
        0  PER       REAL       ARRAY    F.P.         0  Q         REAL       ARRAY    F.P.
        0  XCT       REAL       ARRAY    F.P.

    EXTERNALS          TYPE   ARGS
        ICLS                    3

    STATEMENT LABELS
        0  4                                  0  5

    LOOPS  LABEL    INDEX      FROM-TO    LENGTH   PROPERTIES
       20  5      * I            8 12       178              NOT INNER
       30  4        J           10 11        48    INSTACK

    STATISTICS
      PROGRAM LENGTH                 728      58
            520008 CM USED
```

```
      1                 SUBROUTINE NUMB(NLIM,KC)
                        DIMENSION KC(200)
                        I=0
                   15   READ *,KK
      5                 IF(KK.GT.0)GO TO 11
                        IF(I.LE.0)GO TO 12
                        IB=KC(I)+1
                        IE=IABS(KK)
                        DO 13 J=IB,IE
     10                 I=I+1
                   13   KC(I)=J
                        GO TO 14
                   12   KK=IABS(KK)
                   11   I=I+1
     15                 KC(I)=KK
                   14   IF(I-NLIM)15,20,21
                   20   RETURN
                   21   PRINT 22,I
                   22   FORMAT(* SPECIFIED # IS *,I5)
     28                 RETURN
                        END
```


SYMBOLIC REFERENCE MAP (R=1)

ENTRY POINTS
3 NUMB

VARIABLES	SN	TYPE		RELOCATION				
61	I	INTEGER			63	IB	INTEGER	
64	IE	INTEGER			65	J	INTEGER	
0	KC	INTEGER	ARRAY	F.P.	62	KK	INTEGER	
8	NLIM	INTEGER		F.P.				

FILE NAMES	MODE		
INPUT	FREE	OUTPUT	FMT

INLINE FUNCTIONS	TYPE	ARGS	
IABS	INTEGER	1	INTRIN

STATEMENT LABELS

32	11	30	12			0	13	
36	14	6	15			0	20	INACTIVE
42	21	55	22	FMT				

LCOPS	LABEL	INDEX	FROM-TO	LENGTH	PROPERTIES
24	13	J	9 11	28	INSTACK

STATISTICS
PROGRAM LENGTH 668 54
520000B CM USED

```
SUBROUTINE REFID      74/74   OPT=1                    FTN 4.6+446    08/21/78  15.48.36   PAGE   1

      1               SUBROUTINE REFID(NREF,KREF,RCT,REF,NIS)
                      DIMENSION KREF(200),RCT(NIS),REF(NIS)
                      DO 1 I=1,NIS
                    1 RCT(I)=0.
      5               READ *,NKEF
                      PRINT 121
                  121 FORMAT(* ENTER SAMPLE IDS FOR REFERENCE *)
                      CALL NUMB(NREF,KREF)
                      RETURN
     10               END


      SYMBOLIC REFERENCE MAP (R=1)

ENTRY POINTS
    3  REFID

VARIABLES     SN  TYPE          RELOCATION
   43  I         INTEGER                          0  KREF      INTEGER    ARRAY     F.P.
    8  NIS       INTEGER                F.P.      0  NREF      INTEGER              F.P.
    8  RCT       REAL        ARRAY      F.P.      8  REF       REAL       ARRAY     F.P.

FILE NAMES      MODE
     INPUT      FREE                OUTPUT    FMT

EXTERNALS       TYPE   ARGS
     NUMB                2

STATEMENT LABELS
    0  1                                    36  121     FMT

LOOPS  LABEL    INDEX     FROM-TO     LENGTH     PROPERTIES
   11  1        I           3 4          28      INSTACK

STATISTICS
  PROGRAM LENGTH                 448      36
        52000B CM USED
```

```
      1                SUBROUTINE WINDOW (IID,IW,ICT,LIMW,NIS,BACK)
                       DIMENSION BACK(NIS)
                       DIMENSION IW(NIS),ICT(NIS),LIMW(NIS)
                       DO 18 I=1,NIS
      5          21    IF(IABS(IW(I)-LIMW(I)).LE.3)GO TO 18
                       PRINT 19,IID,I,IW(I),LIMW(1),ICT(I)
                 19    FORMAT(* WINDOW WRONG*/
                      1 5X,*SAMPLE*,I3,*  WINDOW*,I2,*  CENTROID*,I5/
                      2 5X,*SHOULD BE*,I5,*  COUNT*,I6)
     10                PRINT 20
                 20    FORMAT(* ENTER CORRECT CENTROID AND COUNT *)
                       READ *,IW(I),ICT(I)
                       GO TO 21
                 18    CONTINUE
     15          *     CORRECT FOR BACKGROUND COUNTS
                       DO 1 I=1,NIS
                       IF(ICT(I).LE.0)GO TO 1
                       XX=BACK(I)*BACK(I)/ICT(I)
                       XX=ICT(I)-XX
     20                IF(XX.LE.0.)XX=0.
                       ICT(I)=XX+.5
                  1    CONTINUE
                       RETURN
                       END
```

SYMBOLIC REFERENCE MAP (R=1)

ENTRY POINTS
    3 WINDOW

VARIABLES	SN	TYPE			RELOCATION					
0	BACK	REAL	ARRAY	F.P.	126	I	INTEGER			
0	ICT	INTEGER	ARRAY	F.P.	0	IID	INTEGER		F.P.	
0	IW	INTEGER	ARRAY	F.P.	0	LIMW	INTEGER	ARRAY	F.P.	
0	NIS	INTEGER		F.P.	127	XX	REAL			

FILE NAMES	MODE		
INPUT	FREE	OUTPUT	FMT

INLINE FUNCTIONS	TYPE	ARGS	
IABS	INTEGER	1	INTRIN

STATEMENT LABELS

61	1		41	18	75	19	FMT
113	20 FMT		16	21			

LOOPS	LABEL	INDEX	FROM-TO	LENGTH	PROPERTIES
16	18	* I	4 14	268	EXT REFS
51	1	I	16 22	118	OPT

STATISTICS
  PROGRAM LENGTH 1508 104
  520008 CM USED

```
      SUBROUTINE HALF       74/74   OPT=1                    FTN 4.6+446     08/21/78  15.48.36    PAGE  1

     1                SUBROUTINE HALF(IID,ICT,NDEL,NSDEL,DAY,IS,NIS)
                      DIMENSION ICT(NIS),DAY(200),NSDEL(200),HL(5)
                      DATA HL/60.,32.,28.,64.,84./
                C     DATA HL/60.,28.,64.,84.,0./
     5                IF(NDEL.LE.0)RETURN
                      C=ALOG(.50)
                      DO 1 I=1,NDEL
                      IF(IID.NE.NSDEL(I))GO TO 1
                      DO 2 J=1,NIS
    10                HH=HL(J)
                      IF(IS.GT.0)HH=HL(IS)
                    2 ICT(J)=ICT(J)*EXP(C*DAY(I)/HH)+.5
                    * PRINT 3,IID,ICT
                   *3 FORMAT(* SAMPLE*,I5,* -- DECAY CORRECTED COUNTS*,5I7)
    15                RETURN
                    1 CONTINUE
                      RETURN
                      END


      SYMBOLIC REFERENCE MAP (R=1)

ENTRY POINTS
    3  HALF

VARIABLES     SN  TYPE           RELOCATION
   50  C         REAL                          0  DAY      REAL      ARRAY     F.P.
   53  HH        REAL                         54  HL       REAL      ARRAY
   51  I         INTEGER                       0  ICT      INTEGER   ARRAY     F.P.
    6  IID       INTEGER              F.P.     0  IS       INTEGER             F.P.
   52  J         INTEGER                       0  NDEL     INTEGER             F.P.
    0  NIS       INTEGER              F.P.     0  NSDEL    INTEGER   ARRAY     F.P.

EXTERNALS          TYPE   ARGS
      ALOG         REAL      1 LIBRARY                    EXP       REAL      1 LIBRARY

STATEMENT LABELS
   44  1                                    0  2

LOOPS  LABEL    INDEX     FROM-TO    LENGTH     PROPERTIES
   22  1       * I          7 16        258     EXT REFS  NOT INNER
   26  2       * J          9 12        168     EXT REFS

STATISTICS
  PROGRAM LENGTH              778      63
        520000 CM USED
```

```
      1                 SUBROUTINE INV(PER,NIS,Q)
                        DIMENSION PER(NIS,NIS),Q(NIS,NIS)
                        DIMENSION A(5,5),W(10),B(5,5)
                      *
      5               *  COMPUTE INVERSE (PER * PER TRANS ) * PER
                      *
                      *  A = PER * PER TRANS
                        DO 1 I=1,NIS
                        DO 1 J=1,NIS
     10                 A(I,J)=0.
                        DO 1 K=1,NIS
                    1   A(I,J)=A(I,J)+PER(I,K)*PER(J,K)
                      *  INVERSE A
                        CALL LINV3F(A,B,1,NIS,NIS,D1,D2,W,IER)
     15                 DO 4 I=1,NIS
                        DO 4 J=1,NIS
                    4   Q(I,J)=A(I,J)
                        DO 2 I=1,NIS
                        DO 2 J=1,NIS
     20                 B(I,J)=0.
                        DO 2 K=1,NIS
                    2   B(I,J)=B(I,J)+A(I,K)*PER(K,J)
                        DO 3 I=1,NIS
                        DO 3 J=1,NIS
     25             3   PER(I,J)=B(I,J)
                        RETURN
                        END
```

SYMBOLIC REFERENCE MAP (R=1)

ENTRY POINTS
3 INV

VARIABLES	SN	TYPE	RELOCATION							
161 A		REAL	ARRAY			224 B		REAL	ARRAY	
156 D1		REAL				157 D2		REAL		
153 I		INTEGER				160 IER		INTEGER		
154 J		INTEGER				155 K		INTEGER		
0 NIS		INTEGER		F.P.		0 PER		REAL	ARRAY	F.P.
0 Q		REAL	ARRAY	F.P.		212 W		REAL	ARRAY	

EXTERNALS	TYPE	ARGS
LINV3F		9

STATEMENT LABELS
0 1 0 2 0 3
0 4

LOOPS	LABEL		INDEX	FROM-TO	LENGTH	PROPERTIES
20	1	*	I	8 12	258	NOT INNER
21	1	*	J	9 12	228	NOT INNER
34	1		K	11 12	38	INSTACK
52	4	*	I	15 17	153	NOT INNER

LOOPS	LABEL		INDEX	FROM-TO	LENGTH	PROPERTIES
61	4		J	16 17	3B	INSTACK
70	2	*	I	18 22	30B	NOT INNER
71	2	*	J	19 22	24B	NOT INNER
106	2		K	21 22	4B	INSTACK
121	3	*	I	23 25	15B	NOT INNER
130	3		J	24 25	3B	INSTACK

STATISTICS

PROGRAM LENGTH 2768 198

520008 CM USED

```
      SUBROUTINE ICLS(Q,BETA,N)
      DIMENSION Q(N,N),BETA(N),Y(5),Z(5),B(5,5),W(5),IND(5)
      DIMENSION BINV(5,5),WK(10),C(5),SQ(5)
      DO 2 I=1,N
      DO 2 J=1,N
    2 B(I,J)=0.
      DO 1 I=1,N
      Y(I)=0.
      B(I,I)=1.
      Z(I)=W(I)=BETA(I)
    1 IND(I)=1
      DO 4 I=1,N
      DO 4 J=1,N
    4 BINV(I,J)=B(I,J)
    3 ICS=ILET=0
      DO 30 I=1,N
      W(I)=0.
      DO 5 J=1,N
    5 W(I)=W(I)+BINV(I,J)*Z(J)
      IF(ABS(W(I)).LE.1.0E-8)W(I)=0.0
   30 CONTINUE
      IT=0
      XMAX=0.
      DO 6 I=1,N
      IF(IND(I).GT.0)GO TO 6
      IF(W(I).EQ.0.0)GO TO 6
      ICS=1
      IF(XMAX.GE.ABS(W(I)))GO TO 6
      XMAX=ABS(W(I))
      IT=I
    6 CONTINUE
      IF(ICS.GT.0)GO TO 7
      DO 8 I=1,N
      IF(W(I).GE.0.0)GO TO 8
      ICS=2
      IF(ABS(W(I)).LE.XMAX)GO TO 8
      XMAX=ABS(W(I))
      IT=I
    8 CONTINUE
    7 IF(ICS.LE.0)GO TO 100
      DO 60 I=1,N
      SQ(I)=0.
      DO 9 J=1,N
    9 SQ(I)=SQ(I)+Q(I,J)*BINV(IT,J)
      IF(ABS(SQ(I)).LE.1.0E-8)SQ(I)=0.
   60 CONTINUE
      DO 10 I=1,N
      IF(SQ(I).NE.0.0)GO TO 11
   10 CONTINUE
   61 THETQ=SIGN(1.0,W(IT))
      GO TO 17
   11 THETQ=0.
      DO 13 I=1,N
   13 THETQ=THETQ+SQ(I)*BINV(IT,I)
      IF(ABS(THETQ).LE.1.0E-8)GO TO 61
      THETQ=W(IT)/THETQ
   17 ITT=0
```

```
                      T0=1.0E20
                      DO 14 I=1,N
   60                 DEN=THET0*BINV(IT,I)
                      IF(DEN.LE.1.0E-8)GO TO 14
                      IF(Y(I).EQ.0.0)GO TO 14
                      DEN=Y(I)/DEN
                      IF(DEN.GE.T0)GO TO 14
   65                 ITT=I
                      T0=DEN
                14    CONTINUE
                      IF(T0.LE.1.0)GO TO 15
                      THET=THET0
   70                 ILET=1
                      DO 21 I=1,N
                21    B(I,IT)=SQ(I)
                      GO TO 22
                15    THET=THET0*T0
   75                 ILET=2
                      DO 23 I=1,N
                23    B(I,IT)=0.
                      B(IT,IT)=1.0
                22    DO 25 I=1,N
   80                 Y(I)=Y(I)-THET*BINV(IT,I)
                      Z(I)=Z(I)-THET*SQ(I)
                      IF(ABS(Z(I)).LE.1.0E-8)Z(I)=0.0
                      IF(ABS(Y(I)).LE.1.0E-8)Y(I)=0.0
                25    CONTINUE
   85                 DO 24 I=1,N
                      DO 24 J=1,N
                24    BINV(I,J)=B(I,J)
                      CALL LINV3F(BINV,C,1,N,N,D1,D2,NK,IER)
                      IF(ICS.EQ.1.AND.ILET.EQ.2)IND(IT)=1
   90                 IF(ICS.EQ.2.AND.ILET.EQ.1)IND(IT)=0
                      GO TO 3
                100   DO 101 I=1,N
                      DO 200 J=1,N
                200   BETA(I)=BETA(I)+Q(I,J)*Y(J)
   95                 IF(ABS(BETA(I)).LE.1.0E-8)BETA(I)=0.
                101   CONTINUE
                      RETURN
                      END
```

SYMBOLIC REFERENCE MAP (R=1)

ENTRY POINTS
3 ICLS

VARIABLES	SN	TYPE		RELOCATION					
457	B	REAL	ARRAY	0	BETA	REAL	ARRAY	F.P.	
522	BINV	REAL	ARRAY	565	C	REAL	ARRAY		
440	DEN	REAL		442	D1	REAL			
443	D2	REAL		427	I	INTEGER			
431	ICS	INTEGER		444	IER	INTEGER			

VARIABLES	SN	TYPE	RELOCATION						
432	ILET	INTEGER		515	IND	INTEGER	ARRAY		
433	IT	INTEGER		436	ITT	INTEGER			
439	J	INTEGER		0	N	INTEGER		F.P.	
0	Q	REAL	ARRAY F.P.	572	SQ	REAL	ARRAY		
441	THET	REAL		435	THETO	REAL			
437	TO	REAL		518	W	REAL	ARRAY		
553	WK	REAL	ARRAY	434	XMAX	REAL			
445	Y	REAL	ARRAY	452	Z	REAL	ARRAY		

EXTERNALS	TYPE	ARGS
LINV3F		9

INLINE FUNCTIONS	TYPE	ARGS						
ABS	REAL	1	INTRIN	SIGN	REAL	2	INTRIN	

STATEMENT LABELS

0	1	0	2	65	3		
0	4	0	5	127	6		
146	7	144	8	0	9		
0	10	207	11	0	13		
245	14	265	15	226	17		
0	21	304	22	0	23		
0	24	0	25	0	30		
0	60	283	61	365	100		
0	101	0	200				

LOOPS	LABEL		INDEX	FROM-TO	LENGTH	PROPERTIES
28	2	*	I	4 6	138	NOT INNER
25	2		J	5 6	28	INSTACK
41	1		I	7 11	68	INSTACK
51	4	*	I	12 14	148	NOT INNER
56	4		J	13 14	38	INSTACK
70	30	*	I	16 21	238	NOT INNER
77	5		J	18 19	48	INSTACK
128	6		I	24 31	108	OPT
136	8		I	33 39	78	INSTACK
151	60	*	I	41 46	258	NOT INNER
162	9		J	43 44	48	INSTACK
177	10	*	I	47 49	48	INSTACK EXITS
215	13		I	53 54	48	INSTACK
235	14		I	59 67	128	OPT
261	21		I	71 72	28	INSTACK
276	23		I	76 77	28	INSTACK
313	25		I	79 84	148	OPT
331	24	*	I	85 87	148	NOT INNER
336	24		J	86 87	38	INSTACK
366	101	*	I	92 96	228	NOT INNER
374	200		J	93 94	48	INSTACK

STATISTICS

PROGRAM LENGTH 6238 403

520008 CM USED

************ ZA4KGE4 //// END OF LIST ////

************ ZA4KGE4 //// END OF LIST ////

APPENDIX A
OUTPUT FROM GAMMA COUNTER

```
000274 00001.0
000016 000160 000032 001662 000048 000108 000000 013791
000128 000086 000144 000221 000160 000212 000000 003312
000304 000056 000320 000216 000336 000243 000000 003388
000498 000048 000514 000050 000530 000048 000000 000790
001104 000041 001120 000045 001136 000050 000000 000750
```

	Counter ID	Counting time(min)						
Iodine	XXXXXX	XXXXXX	Centroid	XXXXXX	XXXXXX	XXXXXX	XXXXXX	Total CPM
Cerium	XXXXXX	XXXXXX	Centroid	XXXXXX	XXXXXX	XXXXXX	XXXXXX	Total CPM
Chromium	XXXXXX	XXXXXX	Centroid	XXXXXX	XXXXXX	XXXXXX	XXXXXX	Total CPM
Strontium	XXXXXX	XXXXXX	Centroid	XXXXXX	XXXXXX	XXXXXX	XXXXXX	Total CPM
Scandium	XXXXXX	XXXXXX	Centroid	XXXXXX	XXXXXX	XXXXXX	XXXXXX	Total CPM

The centroid is used by the computer to identify the specific isotope with which it is associated.

Total CPM refers to all counts from a specific isotope in the region of interest, accumulated during the counting time--in this case one minute.

APPENDIX B
ABBREVIATED SAMPLE RUN

```
COPRECTED MICROSPHERE COUNTS
 NUMBER OF ISOTOPES ASSUMED TO BE  5
 ISOTOPES I125  CE145 CR141 SR85  SC46
 ENTER SUBJECT ID F-30
 ENTER EXPERIMENT DATE 27 JUNE 78
 ENTER ASSAY DATE 30 JUNE 78
 ISOTOPE  1 I125
      ENTER VOLUME COUNTED .003
      ENTER VOLUME INJECTED .13
      ENTER # SAMPLE IDS 2
      ENTER SAMPLE IDS 1 2
 ISOTOPE  2 CE145
      ENTER VOLUME COUNTED .003
      ENTER VOLUME INJECTED .10
      ENTER # SAMPLE IDS 2
      ENTER SAMPLE IDS 3 4
 ISOTOPE  3 CR141
      ENTER VOLUME COUNTED .003
      ENTER VOLUME INJECTED .28
      ENTER # SAMPLE IDS 2
      ENTER SAMPLE IDS 5 6
 ISOTOPE  4 SR85
      ENTER VOLUME COUNTED .003
      ENTER VOLUME INJECTED .25
      ENTER # SAMPLE IDS 2
      ENTER SAMPLE IDS 7 8
 ISOTOPE  5 SC46
      ENTER VOLUME COUNTED .003
      ENTER VOLUME INJECTED .60
      ENTER # SAMPLE IDS 2
      ENTER SAMPLE IDS 9 10
 ENTER # REFERENCE SAMPLES 14
 ENTER SAMPLE IDS FOR REFERENCE 50 -63
 ENTER WITHDRAWAL RATE, REFERENCE SAMPLE 15.3
 ENTER # SAMPLES FROM RESIDUE   11
      ENTER SAMPLE IDS 11 -15 150 -155
 ENTER # SAMPLES COUNTED PREVIOUS TO ASSAY
     ENTER # SAMPLES AND # DAYS ELAPSED 77 3
      ENTER SAMPLE IDS 1 -10 11 -15 150 -155 50 -63 101 -139 141 -143
     ENTER # SAMPLES AND # DAYS ELAPSED 0 0
 ENTER # SAMPLES IN GROUP  1 8
      ENTER SAMPLE IDS 271 -273
 ENTER # SAMPLES IN GROUP  2 0
 REF CPM       147707     194252     164324     182223     151607
 CORR CPM       15794.     94106.     80233.    152439.    497540.
 SYRINGE  .28140E+07  .35366E+07  .32361E+07  .41069E+07  .69244E+07
```

APPENDIX C
SAMPLE TAPE 2

Counter Location

Code	ID	ID	Wt. (grams)	Io-125	Ce-141	Cr-51	Sr-85	Sc-46	
S	252	52	2.9500	3939.5	7080.8	3671.5	3705.4	15309.	
				1.2937	.39024	.23733	.12607	.15958	
S	253	53	6.2790	8699.7	14804.	10315.	9971.9	43458.	--------Corrected CPM
				1.3422	.38332	.31326	.15940	.21283	--------Blood flow(ml/min/g)
S	254	54	7.2590	7785.1	11460.	5652.8	7613.5	26195.	
				1.0389	.25668	.14850	.10527	.11097	
S	255	55	6.3860	7444.8	12441.	5662.0	5113.6	21875.	
				1.0324	.28953	.15455	.73468E-01	.96290E-01	
S	256	56	5.0220	6176.7	10083.	6252.5	6974.2	27582.	
				1.1915	.32641	.23742	.13938	.16889	
S	257	57	6.3780	9501.1	15414.	7733.1	6549.8	26132.	
				1.3382	.36435	.21440	.95578E-01	.11684	
S	258	58	1.0710	1723.2	2277.9	3175.2	3274.9	21311.	
				1.5587	.34580	.56535	.30690	.61189	
S	259	59	.93400	1289.3	2848.4	3558.0	5198.3	21392.	
				1.3373	.49582	.72644	.55861	.70431	
S	260	60	.50400	803.88	2074.8	2776.3	2988.1	15222.	
				1.5451	.66930	1.0504	.59506	.92079	
S	261	61	2.3790	1753.9	2830.6	1446.7	1138.9	5236.0	
				.71418	.19345	.11596	.48049E-01	.67681E-01	
S	262	62	2.1480	3026.0	5820.2	6280.4	6615.9	32979.	
				1.3647	.44053	.55756	.30914	.47214	
S	263	63	.66700	848.91	991.22	1181.5	1884.0	8789.4	
				1.2329	.24161	.33779	.28350	.40522	
S	264	64	2.6880	2560.2	4315.7	3269.3	3326.6	13043.	
				.92267	.26103	.23193	.12421	.14922	
S	265	65	7.2590	10252.	23348.	27377.	28105.	.12994E+06	
				1.3682	.52294	.71918	.38860	.55045	
S	266	66	14.698	17780.	29916.	19025.	18804.	62598.	
				1.1725	.33109	.24696	.12848	.13104	
G	1	300	86.700	.10920E+06	.20742E+06	.14824E+06	.14835E+06	.50886E+06	
				1.2202	.38896	.32605	.17174	.18049	
S									
F	F-38		27 JUNE 7830	JUNE 78	1900.5	520.92	577.58	382.17	201.3 ---Cardiac output
	Subject		Assay date	Exp. date	Io-125	Ce-141	Cr-51	Sr-85	Sc-46 (ml/min)

Code: S= individual assay
G= group assay
F= cardiac output data

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